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CONTROL OF ATMOSPHERIC EMISSIONS FROM PAINT AND VARNISH MANUFACTURING OPERATIONS

Robert L. Stenburg

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

June 1958

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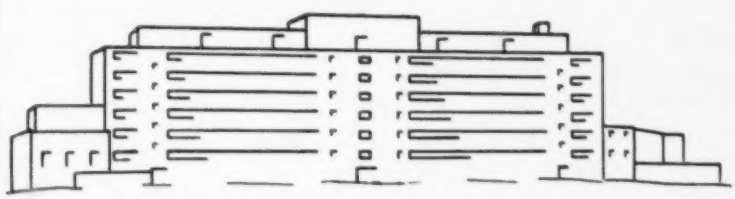

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U.S. DEPARTMENT OF HEALTH,
EDUCATION, AND WELFARE
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CONTROL OF ATMOSPHERIC EMISSIONS FROM PAINT AND VARNISH MANUFACTURING OPERATIONS

A review prepared at the request of the National Paint, Varnish & Lacquer Association.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Bureau of State Services
Division of Sanitary Engineering Services

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CONTROL OF ATMOSPHERIC EMISSIONS FROM PAINT AND VARNISH MANUFACTURING OPERATIONS

by Robert L. Stenburg

Present day protective coatings are the products of precisely controlled chemical reactions and accurately proportioned formulations which may include natural or synthetic drying oils, resins, pigments, volatile solvents, rapid driers, plasticizers, metallic soaps or anti-oxidants. A major component of most coatings is the oil or resin vehicle, the manufacture of which may involve subjecting one or more complex organic materials to chemical reaction at elevated temperatures in order to attain the properties desired for a particular application. During these reactions, or cooking operations, there is some decomposition of the basic constituents with the result that a portion of the kettle ingredients is vaporized or otherwise lost to the surrounding atmosphere to be carried off in the form of gases, liquids and solids. Other atmospheric losses in this industry result from (1) the hot or cold thinning of lacquers, varnishes, resins and oils with volatile solvents and thinners to provide a proper consistency to the intermediate or end product, and (2) the storage or handling of both raw materials and intermediate products.

Because of the large volume and wide variety of oils and resins processed, and because of the type and amount of materials lost to the atmosphere during the high temperature cooking processes, the production of paint and varnish vehicles establishes itself as the principal source of atmospheric pollution in this industry. The term "fumes" is commonly applied to these cooking losses. Since recovery of these fumes has so far proven uneconomical, they are usually collected by hoods, enclosures and duct systems and are discharged to the outside air either directly or after some degree of treatment. Many of the chemicals discharged are undesirable as atmospheric constituents, and fall into the category of air pollutants. Under certain atmospheric conditions the undesirable quality of some pollutants in the air is compounded by chemical interaction and is intensified

by sunshine. Increasing concern of health officials regarding air pollution and the growing demands by the general public for increased air pollution controls make it desirable to review some of the problems and considerations involved in determining the type and degree of air pollution controls which are or may be required in this industry.

REASONS FOR CONTROL

Although the immediate health effects of air pollutants are of prime importance in establishing the need for air pollution control, other factors include aesthetic considerations of man's environment and damage to vegetation and property. The situation requiring control of undesirable atmospheric emissions may vary from plant to plant and from locality to locality. Control may be voluntary or it may be enforced as a result of a legalized air pollution control agency, public pressure, or court order. Following are the specific conditions which may require air pollution control at a given plant:

1. Toxic Materials

The discharge of gases, vapors, or particulates into the atmosphere which are toxic or otherwise injurious to humans, animals or vegetation will obviously require immediate control.

2. Smoke and Dust

Smoke and fly ash from combustion processes have long been recognized as undesirable atmospheric components. Most air pollution control ordinances specifically limit the discharge of these materials into the atmosphere.

3. Objectionable Odors

Whenever materials having objectionable odors are

discharged to the atmosphere, they create an undesirable environment. A malodorous material need not be injurious to health to be considered undesirable. For legal purposes, odors are generally classified as nuisances, and ordinances prohibiting nuisances exist at almost every level of government. Ample evidence exists to indicate the attitude of courts in holding creators of odor nuisances responsible for the control of such odors. A number of the organic raw materials used in the protective coatings industry, and many of the decomposition and distillation by-products from such processes as heat polymerization and esterification of oils and resins, have highly disagreeable odors. The reduction or elimination of these odors is the principal reason that control of atmospheric emissions is required of this industry.

4. Property Damage

Materials discharged to the atmosphere may be chemically active liquids, solids or gases capable of reacting with such construction materials as stone, brick, cement, metals and surface coatings. Their effects will often be most noticeable on structures and automobiles immediately adjacent to the plant where they are discharged. One example of property damage resulting from vehicle production is the cooking of drying oils with phthalic anhydride. Water scrubbed fumes from the varnish kettles have been known to condense and freeze on the inside of exhaust ducts. With warming of the metal ducts, the ice breaks loose and becomes finely pulverized on passing through the exhaust fans. As a result, a fine aerosol of ice particles containing phthalic anhydride is discharged to the atmosphere and cars parked in the vicinity of the plant may suffer extensive pitting of the exterior paint as these particles settle.

5. Smog Formation

The atmospheric phenomenon commonly known as "smog" results from a combination of factors including the irradiation of atmospheric pollutants under proper

meteorological conditions. While this process is not yet entirely understood, the materials presently thought to be of greatest importance in producing "smog" include oxides of nitrogen, unsaturated hydrocarbons (particularly olefinic) and ozone. Smog is most likely to occur in areas where a variety of chemical industries discharge large quantities of hydrocarbons to the atmosphere. Stagnant meteorological conditions which permit the concentration of pollutants to build up in the atmosphere and simultaneously provide a lengthened atmospheric reaction time appear to be additional factors conducive to smog formation.

DEGREE OF CONTROL REQUIRED

When odor problems are involved, the degree of control required may depend much on plant location. For example, objectionable odors emanating from a plant in or near a residential area will eventually become the object of complaints which sooner or later force the plant to effect sufficient controls to stop the complaints. Another plant using the same raw materials and manufacturing processes but in a less populated or strictly industrial location may get by without the need for controlling their emissions simply because the discharged material undergoes sufficient dilution to render the odors much less noticeable by the time they reach populated areas.

SOURCES OF ATMOSPHERIC POLLUTION

Except for pigments, the majority of materials used in the manufacture of protective coatings are of organic composition with varying degrees of volatility; therefore, their storage, handling, mixing, and processing will produce different amounts of atmospheric pollution depending on the particular raw materials used, the combinations in which they are mixed, and the conditions to which they are subjected. Coatings are individually developed to satisfy an unusually wide variety of applications, and the basic vehicle is compounded to acquire special properties by adjusting both its chemical composition and the cooking procedure required for its production. As a result there are

innumerable combinations of organic mixtures and time-temperature cooking procedures being used in the industry.

1. Cooking Processes

In the manufacture of paint and varnish vehicles, cooking is employed for bodying natural and synthetic oils; for the preparation of straight and oil-modified alkyds; for processing short, medium and long oil varnishes; for polymerizing acrylic monomers; and for the conditioning of many other products. Through such reactions as oxidation, polymerization and esterification, the raw materials are transformed, by the application of heat, from their previous states to varying consistencies and compositions. Commonly used natural oils include linseed, soybean, perilla, tall, caster, oiticica, fish, olive and tung, while additives may include glycerine, phthalic anhydride, litharge, fumaric acid, pentaerythritol, various resins including rosin and many other substances depending on the process involved and the properties required of the final product. Cooking temperatures range from 200°F. up to 600°F. and are ordinarily maintained for several hours. Eight to twelve hours is an average length of cook, although some processes require heating for as long as 24 hours.

Decomposition of the kettle ingredients by vaporization, cracking, destructive distillation and chemical reaction produces fuming. This starts at around 350°F. in the average oil or varnish kettle. The rate of fuming rises with temperature increase and reaches its maximum when or shortly after the highest processing temperature is reached. Fuming continues so long as heating is continued. Gases so released may combine with solid or liquid particles by absorption or adsorption. Liquid droplets may become entrained in bubbles leaving the reactant to be picked up by the gas or air stream passing over the kettle. Solid particles may escape in the form of dust, as wetted particles in liquid droplets, or, if soluble, as droplets of solution.

Losses to atmosphere will vary depending on composition of ingredients, rate of temperature

application, maximum temperature attained, method of introducing additives, degree of stirring, type and extent of air or inert gas blowing, and length of time kettle is held at maximum temperature. Maximum losses normally occur during the high temperature cycle of the cook. Total loss of oleoresinous varnish cooks may average 3 to 6% with some losses reported as high as 10-12%. Losses from the production of alkyd resins may range from 4-6%. Cooking and blowing of oils may produce from 1 to 3% loss, while heat polymerization of acrylic resins may run less than 1%, unless the reaction gets out of control and overflows the kettle.

Most modern plants employing high temperature processes use closed kettles vented through a duct system to a central discharge point. Some smaller plants still use open kettles, but these are usually hooded and vented through a duct system.

The composition of fume constituents given off during heat processing of the four major classes of oils and varnishes as listed by J.J. Mattiello (16) is shown in Table 1. Using infrared spectrometer techniques, C.W. Selheimer, et al (12)(13), identified the functional groups present in the fumes from several high temperature polymerization and esterification processes (Table 2).

In the heat bodying of natural oils, saturated and unsaturated aldehydic substances are among the decomposition products produced. The harsh, pungent odors of short chain aldehydes are typical by-products of this as well as other cooking processes involving such oils. In addition to their objectionable odor properties, unsaturated aldehydes cause eye watering and mose and throat irritation. Acrolein (or acrylic aldehyde) which was used as a tear gas in World War I, is an unsaturated aldehyde commonly identified with oil cooking processes and is readily recognized by its disagreeable odor and irritating qualities. This is a decomposition product of glycerine which may have been included in the reactant as an additive or produced by breakdown of the oil during heating. Unsaturated aldehydes, acids and esters are likewise produced in varying degrees during the manufacture of oleoresinous varnishes and alkyd resins. The decomposition and

Table 1. COMPOSITION OF OIL AND VARNISH FUMES

Bodying oils	Running natural gums	Manufacturing oleoresinous varnish	Manufacturing alkyd varnish
Water vapor	Water vapor	Water vapor	Water vapor
Fatty acids	Fatty acids	Fatty acids	Fatty acids
Glycerine	Terpenes	Glycerine	Glycerine
Acrolein	Terpene oils	Acrolein	Phthalic anhydride
Aldehydes	Tar	Phenols	Carbon dioxide
Ketones		Aldehydes	
Carbon dioxide		Ketones	
		Terpene oils	
		Terpenes	
		Carbon dioxide	

Table 2. ODOR AND COMPOSITION (BY FUNCTIONAL GROUPS) OF OIL AND VARNISH FUMES

Process and temperature	Kettle ingredients	Compounds identified	Odor
Heat polymerization of Linseed oil 575°F.	Linseed oil Admolene (a catalized linseed oil)	Saturated and/or unsaturated Aliphatic fatty acids Aldehydes Aliphatic Esters Paraffins Olefins	Harsh, pungent odor characteristic of short chain aldehydes (cause eye watering to varying degrees)
3 Dark Linseed Oil 580°F.	Raw Linseed Oil	Saturated and/or unsaturated carboxylic acids Aliphatic esters Alkyl aldehydes Paraffins Olefins Unsaturated: Acids Esters Aldehydes	
O-Pale linseed oil 580°F.	Alkali refined linseed oil	Saturated and/or unsaturated aliphatic fatty acids Olefins	

1-Pale linseed oil	Alkali refined linseed oil	Saturated and/or unsaturated: fatty acids Saturated Aldehydes Olefins	
00-Pale linseed oil	Alkali refined linseed oil	Saturated and/or unsaturated: aliphatic carboxylic acids Unsaturated alkane esters Saturated alkyl aldehydes Olefins	
Tall oil alkyd 475°F.	Tall oil Glycerine Fumaric acid	Saturated and/or unsaturated: Carboxylic acids Esters Aldehydes Alcohols Paraffins Olefins Fumaric acid	Hydrogen Sulfide (Rotten egg odor)
Tall Oil Alkyd 560°F.	Tall Oil Glycerine Pentaerythritol		Very offensive - Hydrogen Sulfide, n-butyl mercaptan (skunk odor)

Soybean oil alkyd 475°F.	Soybean oil Glycerine Fumaric acid Rosin	Saturated and/or unsaturated Aliphatic carboxylic acids Aliphatic alcohols Alkyl aldehydes Alkane esters Paraffins Olefins	Mild soapy & slightly lemon-like odor
Linseed oil alkyd 475°F	Alkali refined linseed oil Glycerine Phthalic anhydride Litharge	Aromatic acids Aromatic esters Aromatic aldehydes Aliphatic Carboxylic acids Aliphatic Aldehydes Aliphatic alcohols	Typical linseed oil cooking odors (harsh and stinging)

reaction products of various additives to any process make their own distinctive contributions to the escaping fumes.

In the tall oil glycerine pentaerythritol esterification process, small quantities of sulfur in the tall oil are responsible for the creation of highly offensive odors in the fumes produced. Hydrogen sulfide is given off during the heating up period and n-butyl mercaptan (skunk odor) is produced during the high temperature cycle. The hydrogen sulfide odor from this process becomes more pronounced as the temperature of the cook is increased. Some suppliers are now refining tall oil in an effort to remove as much of the sulfur as possible before it is used in vehicle production.

It is of interest to note that both tall oil and pentaerythritol contain only carbon, hydrogen and oxygen (with a small amount of sulfur in the tall oil); however, the degradation or oxidation products comprising the fumes from the esterification of these materials might contain several thousand compounds including aldehydes, ketones, hydrocarbons, the sulfur compounds mentioned, and various organic acids such as ordinary saturated and unsaturated hydroxy, aldehydic, dicarbonylic and ketonic acids. The sulfur compounds, like a number of other malodorous components which create the primary air pollution problem from cooking processes, occur in concentrations which ordinarily cannot be detected by wet chemistry, infrared or mass spectrometry techniques, but are readily detected by the human nose.

The development of water emulsion and water soluble coatings in recent years has resulted in additional raw materials being used for making vehicles, and, as might be expected, this has brought about an increase in atmospheric odor problems. For example, in manufacturing latex coatings involving the polymerization of certain acrylic monomers such as methyl methacrylate, the monomer itself is highly volatile and has a strong sickening sweet odor. Control of the vapors from this raw material during storage and handling must be as complete as the control of fumes produced during polymerization.

Many of the odor problems resulting from the manufacture of paint and varnish vehicles are made exceedingly difficult because the malodorous compounds involved have very low odor thresholds and thereby create objectionable odor conditions even though they exist in extremely dilute concentrations. Many such compounds have noticeable odors in concentrations of one part per million and less (Table 3).

Table 3. ODOR THRESHOLD CONCENTRATIONS

Material	Concentration ppm	Odor
Acrolein	1.8	Acrid odor
Crotonaldehyde	0.062	Eye and nose irritant
Acetaldehyde	0.066	Eye and nose irritant
Methyl methacrylate	1.0	Sickening sweet
N-butyl mercaptan	0.001	Skunk odor
Hydrogen sulfide	0.13	Foul (rotten eggs)
Allyl sulfide	0.00014	Garlic odor
Sulfur Dioxide	1.0	Pungent

2. Mixing and Thinning Processes

The addition of solvents and thinners to oils, resins, varnishes and lacquers may be an important source of air pollution where large quantities of highly volatile materials are involved. Many processes require the addition and mixing of solvents during the cooking process, in which case the amount of solvent lost to the atmosphere will be governed by its volatility, the temperature of the material to which it is added, the degree of mixing, and the extent of additional heating, if any.

Thinning of premixed paint pastes to the consistency required by the user involves dilution with aliphatic or aromatic hydrocarbons, alcohols, ketones, esters and other materials which are highly volatile at normal temperatures. Although some plants use open vat mixing with certain solvents, the volatility of most thinners requires that mixing be done in totally enclosed tanks to prevent appreciable losses of these expensive products. In general, the loss of solvents to atmosphere from such mixing amounts to no more than 1 or 2% of the solvent used.

The addition of powdered solids for mixing or reaction with paint and varnish vehicles can be a source of atmospheric dust pollution unless such materials are properly handled. Pulverized pigments may be carried through the exhaust system and discharged to the atmosphere if suitable controls are not used. The batch addition of other powdered materials such as phthalic anhydride to cooking kettles may produce a dust discharge of several minutes' duration even with a scrubber on the vent system.

3. Miscellaneous sources

While the principal atmospheric pollution from a vehicle manufacturing plant results from the venting of cooking and mixing vats, there may be other minor sources of pollution within the plant, the importance of which will depend on the raw materials used, plant location, type of air pollution created and the seriousness of other sources. Factors such as spillage, leakage, or loss from vaporization of stored materials may make a greater contribution than casual observation would indicate. Each problem will require evaluation and solution on the basis of all the factors involved. An example of the extent to which control may be required is the case of a plant using large quantities of methyl methacrylate; it is located in a semi-residential area and was at one time subjected to numerous complaints. After evaluating every possible source of odor, this plant has been forced to adopt special precautions at all stages of storage and handling, and now considers the spillage of 1/2 pint of the raw monomer

a serious offense. Every precaution is taken against spillage and valve leakage. Special leak-proof connectors are used on the hose when emptying the tank truck into the storage tank. The saturated vapor exhausted from the raw monomer storage tank is vented through activated charcoal to prevent its escape to the atmosphere each time the tank is filled. Additional activated charcoal adsorbers are placed over the tank truck manhole opening and over the vent discharging from the monomer mixing room. Special instructions were furnished the supplier to insure delivery of the raw material in a tank truck free from odor and with all valves tightly closed against the slightest leakage.

METHODS OF CONTROLLING ATMOSPHERIC EMISSIONS

On the basis of experience gained through trial and error, several fairly good methods for the disposal of fumes from cooking operations have been developed. They are:

1. Condensation and absorption by scrubbing with water.
2. Condensation and absorption by scrubbing with alkali or acid washes.
3. Combustion.
4. Dispersal from high stacks.

No one control method has proved suitable for all applications. Many control devices now being used are, at best, only partially effective.

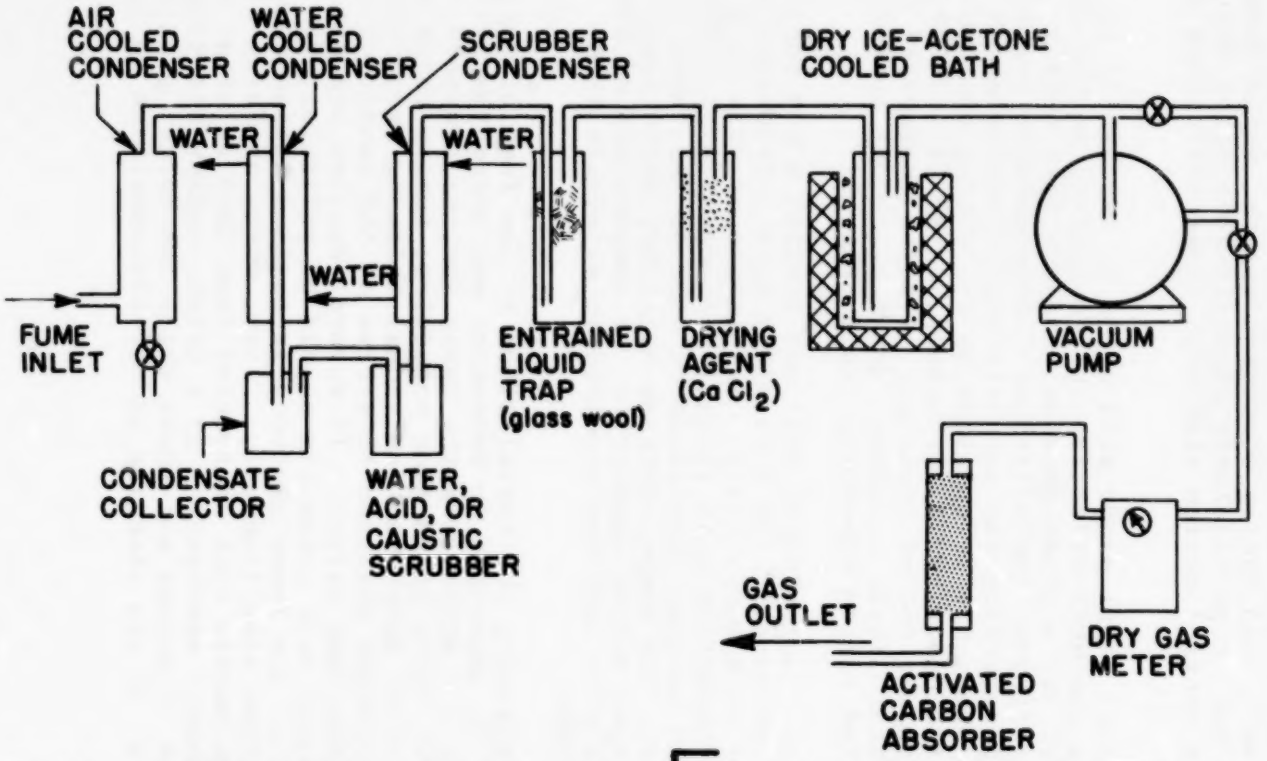
Fumes from cooking processes are composed of a heterogeneous mixture of gases, vapors, and particulates (both liquid and solid). Any one of these types of contaminants, by itself, might be effectively controlled by a single appropriate method. However, such a mixed composition does not lend itself well to highly effective control by any single method other than combustion. Although comparatively high fume removal efficiencies may be obtained with scrubbers in terms of the total mass of

fumes collected, the bulk of material removed, may be innocuous water and easily condensed vapors, while those components having particularly objectionable odors may pass through the control device with much lower efficiency of removal.

A pilot plant study will often be worthwhile in determining the most effective and economical method of fume control for a given process, and may save costly or grossly inefficient installations. Considerable practical information regarding the composition and character of fumes from any process may be obtained by collecting samples with the apparatus described by Selheimer, et al (4)(5)(13), employing an air cooled condenser, a water condenser, a water or other liquid scrubber, dry ice-acetone condenser and activated carbon adsorption unit (Fig. 1).

Pilot plant studies will not predict every condition which will arise with the full scale unit. Allowance should be made for this possibility. An example of this is a catalytic combustion unit installed to operate at 750°F. Although the initial objectionable odor of the fumes was destroyed at this temperature, a secondary objectionable odor developed during combustion. A temperature of 950°F. in the catalytic unit was required to eliminate this secondary odor.

In planning the installation of the fume disposal system, it is important to determine and correctly evaluate all the factors which form the basis for the proposed design. The daily production schedules, fuming rates of each particular batch and individual thinning procedures must be carefully analyzed to arrive at the condition of total maximum fume output. If several kettles are attached to one control unit, capacity should be sufficient to handle all of the fumes produced if maximum fuming occurs in all kettles simultaneously. Also, extra capacity must be provided to handle such unexpected fume load as might occur from accidental overheating of a batch, sudden starting of an agitator, a sudden air blast while the batch is at high temperature, or the charging of certain additives in large doses.



FUME SAMPLING APPARATUS [AFTER SELLHEIMER, et al (4,7,13)]

FIGURE 1

1. Liquid Scrubbing

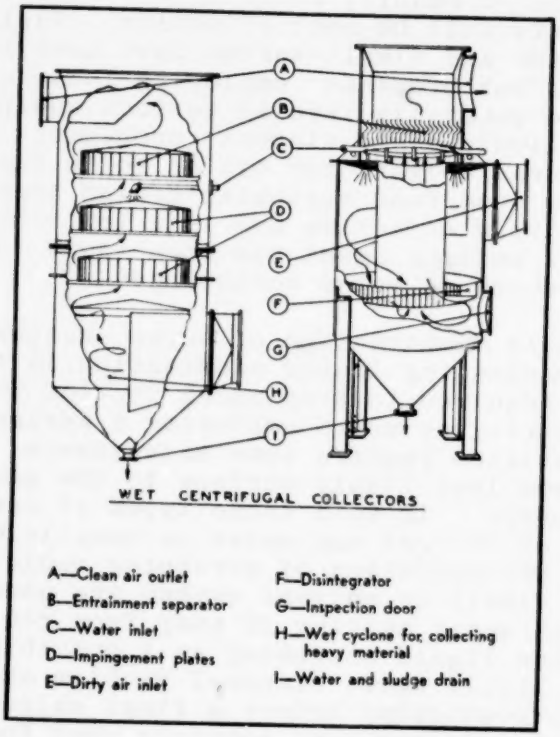
Scrubbing effects a condensation and an absorption of the fume components. Therefore, intimate contact between the liquid phase and the gas phase is essential, and a liquid capable of readily absorbing or reacting with the fume components will be most effective. Various oils, solvents, acids and alkali washes have been tried on a limited basis but processes employing these materials are expensive and generally involve serious equipment maintenance and liquid waste disposal problems. Although water is not the ideal solvent for oil or resin fumes, it is the most commonly used fume scrubbing medium because it has proven relatively effective and is a low cost solvent. The addition of a wetting agent has been found to increase the effectiveness of water scrubbing.

The main disadvantage of spray chambers or towers employing nozzles for liquid atomization is the high maintenance required to keep spray nozzles working properly. Scrubbing chambers employing a series of baffles and water curtains require less maintenance. However, this method exposes less liquid surface to the gas stream than atomizing sprays. In both these types of scrubbers counterflow of the gas and water is usually employed. (Fig. 2.). Recirculation of scrubbing media is required where acid, alkali or solvent washes are used. Present practice with water washing is away from recirculation. In considering liquid scrubbing as a possible fume control method, the liquid waste disposal problem should be thoroughly investigated before a final selection is made. Packed towers have not been commonly used for fume control because the tarry and gummy nature of the condensed fumes soon fills the spaces between the packings.

Selheimer (12) reports overall collection efficiencies ranging from 85 to 98% for a multi-stage impinger type water scrubber with turbine-like vanes when used to scrub fumes from several oil and varnish cooking processes.

2. Incineration

Disposal of fumes from the cooking of oils and resins



LIQUID SCRUBBER

FIG. 2

by combustion is perhaps the most effective single method of removing all forms of the heterogeneous fume mixture previously mentioned. Except for a certain amount of water, the fumes are mostly organic in composition and are therefor fully combustible. If complete oxidation of the hydrocarbons to H_2O and CO_2 can be achieved, many, if not all, of the obnoxious and odorous materials will be converted to innocuous compounds which are considered normal constituents of the atmosphere.

Fumes having a given chemical composition will have characteristic ignition or combustion temperatures, but this composition (like the kettle temperature and fuming rate) may change as the cooking cycle progresses. Therefore, the temperatures required for complete combustion may also vary during a cycle. Temperatures in a direct flame fume burner, generally range from 1100 to 1200°F., although temperatures up to 1500°F. have been required at times (Table 4). As a general rule, ignition temperatures become higher with an increase in water vapor and CO_2 content of fumes. Sufficient oxygen must be available for complete combustion, and the gas stream must be maintained at temperature long enough for the reaction to go to completion.

There is some evidence gained from field observations to indicate that low concentrations of organic waste materials passed through live flames undergo complete oxidation more readily than when raised indirectly to the combustion temperature. Studies are presently under way by the U.S. Bureau of Mines on certain pure compounds to determine the validity of this observation.

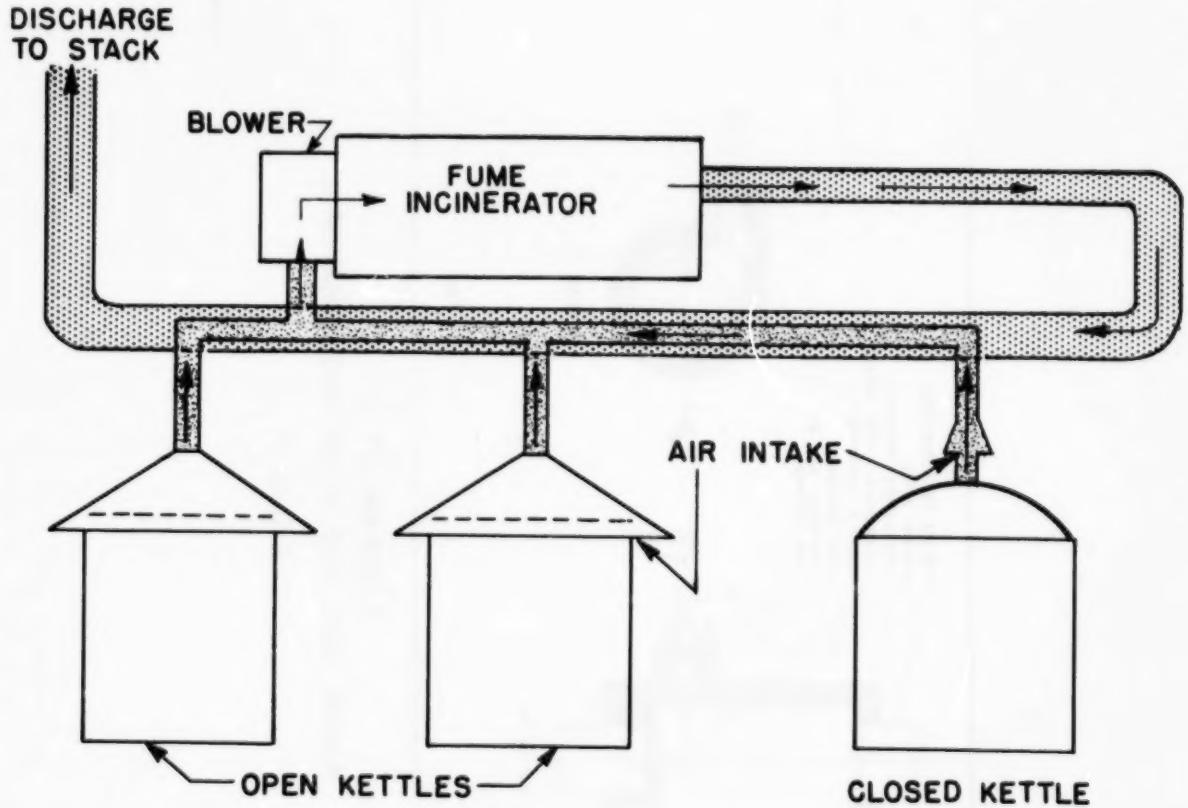
A complete system of fume disposal by combustion consists of kettle covers, a main fume duct with branch lines to the individual kettles, and a fume-burning furnace consisting of a gas or oil-fired fume-ignition zone and a fume combustion zone (Fig. 3.). This latter zone is provided with additional radiating surfaces to insure complete combustion of slow-burning or wet fumes. An exhaust system utilizing a natural draft type chimney, an exhaust blower or an ejector system is required to convey the fume-air mixture from the kettles through the furnace and release the spent flue gases into the atmosphere.

Table 4. FUME IGNITION TEMPERATURES
From Jares (1)

MATERIALS	DEGREES F.
Linseed oil (raw)	1,150
Linseed oil (refined)	1,130
Linseed and fish oils (50-50 mixture)	1,140
Z-3 linseed and Z-3 castor oils (50-50 mixture)	1,120
Alkyd--tall oil--pentaerythritol	1,280
Varnish formulations	980 to 1,160

Fuel consumption of a fume incinerator depends on design, rated fume capacity and draft conditions of the system. A correctly proportioned and well insulated furnace (Fig. 4.) requires a fuel input between 600 and 1200 BTU per hour per gallon of processed batch. During the maximum fuming rate of the cooking cycle in certain processes, enough fumes will be produced to appreciably supplement the regular fuel. In such cases a temperature controller is used to restrict fuel input and the heat generated by combustion of the fumes helps maintain the furnace at the required temperature. Fuel savings up to 80 percent of the rated burner capacity have been reported by Jares (1).

In using combustion processes for disposing of fumes, adequate consideration must be given to the possibility of fire or explosion in the kettle as a result of flashback through the vapor or by ignition of condensed duct deposits. Insurance underwriters will disapprove fume control by combustion on particularly hazardous processes, and will require that adequate



LAYOUT OF FUME COMBUSTION SYSTEM
FOR PAINT AND VARNISH COOKING

FIGURE 3

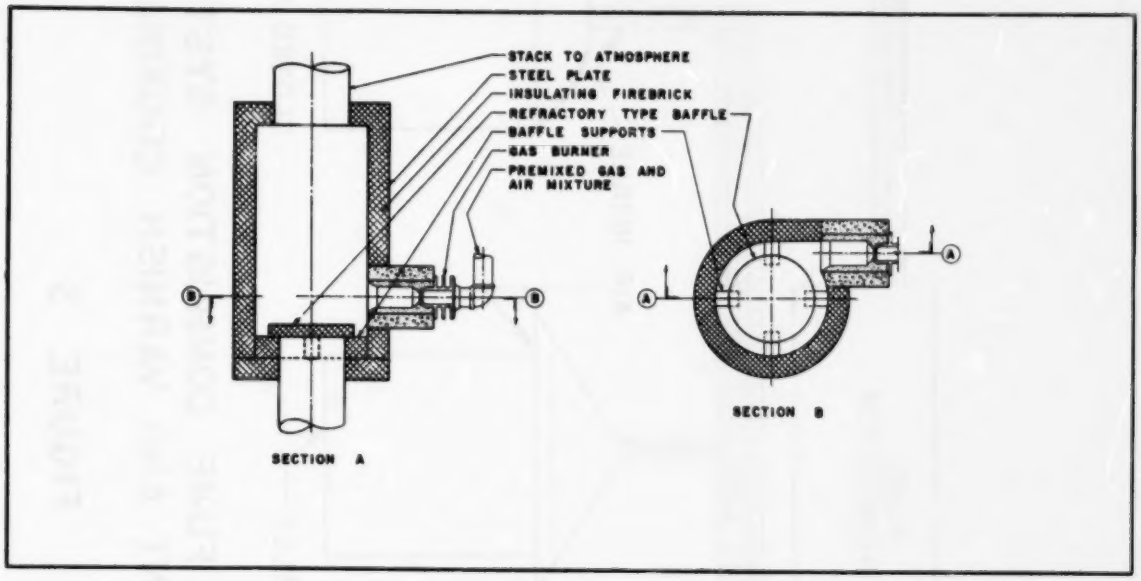


DIAGRAM OF A
WASTE GAS AND ODOR INCINERATOR

FIGURE 4

16-500129

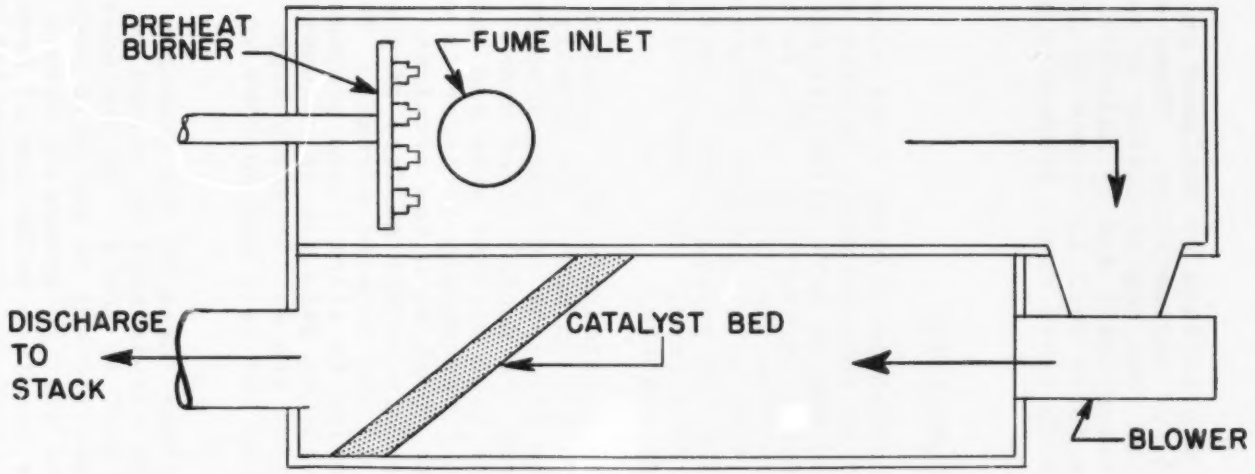
flashback or burnback precautions be included on those installations approved for incineration. These may be achieved by diluting the fume concentration to less than 25% of the lower explosive limit and by maintaining gas velocities in the fume ducts well in excess of 20 ft. per second, the rate at which flame could propagate along the duct.

3. Catalytic Combustion

Catalytic combustion is gaining wider acceptance as an effective method of fume disposal as more suitable catalysts are developed and as more effective reduction of odorous fume components is required. The catalytic combustion unit differs from the direct flame incinerator only by the addition of a catalyst bed which serves the function of reducing the autoignition temperature of the fumes (Fig. 5.). As a result the catalytic unit operates at a lower temperature.

The most effective catalysts are vanadium and platinum compounds. Catalytic media are usually made with a thin coat of the catalyst covering asbestos strips or porcelain, refractory, or nickel alloy rods. They are designed to produce high surface area and employ various shapes and bed arrangements in order to obtain intimate contact of the fumes with the catalyst surface. Combustion occurs on the surface of the media. The heat is liberated to the exhaust stream. When fume concentrations are too low to allow flame propagation, there is normally no visible evidence of combustion, but where fume concentrations are sufficiently high, the heat of combustion will cause the catalyst to come to a dull red color.

In order to oxidize fumes in the presence of a catalyst the entire gas stream must be raised to a temperature ranging from 500° to 600°F. If the exothermic heat of reaction is insufficient to maintain such temperatures, the gases must be preheated before entering the catalyst bed. The complete oxidation of some malodorous components often requires preheating of the gas stream up to 1000°F.



SCHEMATIC ARRANGEMENT OF CATALYTIC FUME BURNER

FIGURE 5

For safety purposes the catalytic combustion unit requires the same dilution of the fume stream as the non-catalytic incincerator.

Some combustion processes are being installed with the duct between kettles and incinerator enclosed inside the flue carrying incinerator flue gases to the outside atmosphere. This arrangement provides a heated duct for transporting fumes from the kettles and eliminates clogging of ducts from fume condensation.

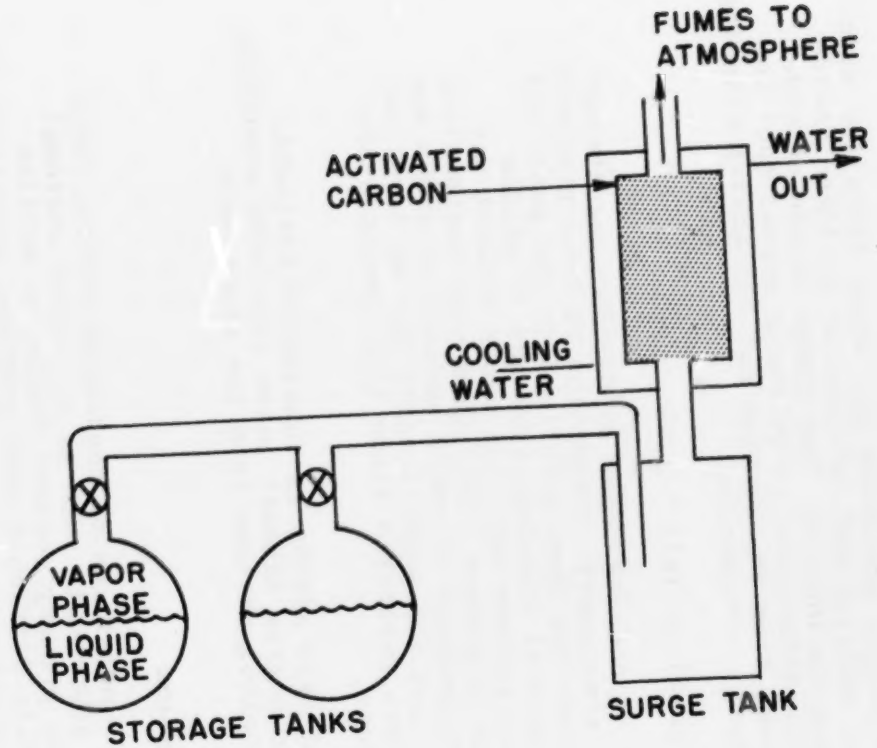
4. Dispersal by Tall Stacks

Disposal of cooking fumes by discharging through tall stacks for atmospheric dispersion without preliminary control devices has been practiced in the past, but the method has several disadvantages and is seldom considered a satisfactory solution under present day requirements. On processes other than high temperature cooking, stack dispersion of small amounts of gases and vapors which are not too objectionable may be justified in localities where favorable winds blow continuously throughout the year.

The use of tall stacks is considered advisable, however, for discharging exhaust gases from both scrubbing and combustion control devices into the atmosphere.

5. Adsorption

The gummy composition of condensed cooking fumes makes the use of adsorbents such as activated charcoal impractical as the primary control device on kettles. However, for certain difficult odor problems adsorption is a highly effective control measure, particularly where small volumes of gases containing high odor intensity materials must be treated. With the development of new processes and the use of new materials, activated carbon may be expected to find even wider usage. Its use in controlling methyl methacrylate vapor released from storage tanks and tank trucks has already been mentioned (Fig. 6.).



ARRANGEMENT FOR VENTING LIQUID CHEMICAL STORAGE TANKS THROUGH ACTIVATED CARBON ADSORPTION CARTRIDGE

FIGURE 6

Adequate safety precautions must be observed in the use of adsorbents since an appreciable heat of adsorption is developed which could cause ignition of the vapors. This heat can be kept at safe levels by cooling the activated carbon cartridge and by regulating the rate at which the vapor is released to the adsorbent.

OTHER METHODS OF REDUCING ATMOSPHERIC POLLUTION:

Although control devices will normally be required for reducing the major sources of atmospheric pollution, other possibilities for effecting a reduction in pollutants should be thoroughly investigated to insure the most practical and economical solution. The substitution of raw materials with less odor-causing impurities or fewer objectionable decomposition products may sometimes be possible without seriously altering the basic properties of the vehicle being produced. The refinement of tall oil to remove sulfur is an example of what can be accomplished along these lines. Minor process modifications or changes may be effective in reducing the discharge of odorous or irritating components accompanying normal fuming. These may include rate of heat application, maximum temperature of cook, or length of time kettle is held at maximum temperature. It has already been noted that the release of H_2S from the cooking of tall oil seems to increase with temperature.

A detailed survey of the raw materials used, the storage and handling facilities and the processes employed throughout the plant may suggest other ways of reducing the overall contribution to atmospheric pollution. In considering the manufacture of new products, the air pollution potential of the raw materials to be used and the new processes to be employed should be thoroughly evaluated under production conditions.

Individual plant and group research similar to the study (4) sponsored by the Chicago paint and varnish manufacturers will be of great value in solving specific problems and reducing the cost of air pollution control. Although fumes have heretofore been considered uneconomical to recover, the added cost of pollution control may eventually make their recovery more feasible economically.

The establishment of industrial zoning areas designated by air pollution control agencies on the basis of favorable movement of atmospheric air masses away from centers of population, may sometimes require less stringent controls on fume emission from plants located in such areas. However, this approach to air pollution control can only be put into effect after suitable study to determine if such zoning is feasible.

SUMMARY

Air pollution problems associated with the manufacture of protective coatings result primarily from the high temperature processing of natural and synthetic oils and resins to produce paint and varnish vehicles. The release of malodorous materials is the most widespread problem and the most difficult to control. Since fume components are predominantly of hydrocarbon composition, they have the potential to contribute to the formation of smog in those areas where air pollution is well established. Property damage is also a definite possibility from some of the processes employed.

The majority of fumes from cooking processes may be controlled by liquid scrubbing or by incineration, the latter being more effective in reducing the small but offensive portion of the total fume output that is largely responsible for the odor problem. Activated carbon adsorption is effective on certain highly odorous materials on processes other than cooking.

These and other types of controls are in general usage throughout the industry and are serving to greatly reduce the amount of undesirable materials discharged to the atmosphere.

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